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## 'Time of Flight Angiography'

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## MRI Resources

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## Time of Flight Angiography



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## MRI Harm - Contrast Agent

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(TOF) The time of flight angiography is used for the imaging of vessels. Usually the sequence type is a gradient echo sequences with short TR, acquired with slices perpendicular to the direction of blood flow.

The source of diverse flow effects is the difference between the unsaturated and presaturated spins and creates a bright vascular image without the invasive use of contrast media. Flowing blood moves unsaturated spins from outside the slice into the imaging plane. These completely relaxed spins have full equilibrium magnetization and produce (when entering the imaging plane) a much higher signal than stationary spins if a gradient echo sequence is generated. This flow related enhancement is also referred to as entry slice phenomenon, or inflow enhancement.

Performing a presaturation slab on one side parallel to the slice can selectively destroy the MR signal from the in-flowing blood from this side of the slice. This allows the technique to be flow direction sensitive and to separate arteriograms or venograms. When the local magnetization of moving blood is selectively altered in a region, e.g. by selective excitation, it carries the altered magnetization with it when it moves, thus tagging the selected region for times on the order of the relaxation times.

For maximum flow signal, a complete new part of blood has to enter the slice every repetition (TR) period, which makes time of flight angiography sensitive to flow-velocity. The choice of TR and slice thickness should be appropriate to the expected flow-velocities because even small changes in slice thickness influences the performance of the TOF sequence. The use of sequential 2 dimensional Fourier transformation (2DFT) slices, 3DFT slabs, or multiple 3D slabs (chunks) are depending on the coverage required and the range of flow-velocities.

3D TOF MRA is routinely used for evaluating the Circle of Willis.

See also Magnetic Resonance Angiography and Contrast Enhanced Magnetic Resonance Angiography.



Further Reading:

MR  
Ups

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- ▶ Symbols
- ▶ Units & M.

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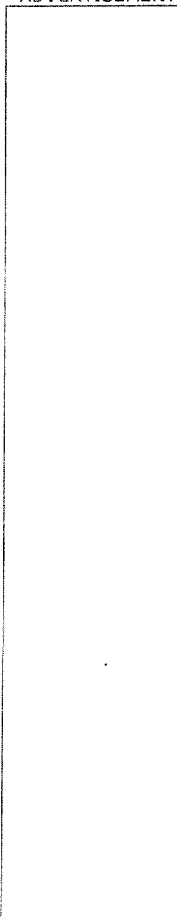
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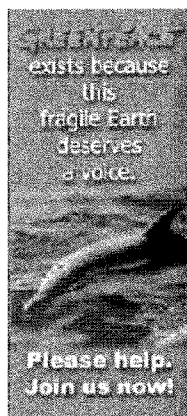
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See a comprehensive list of sequences!

## Basics:

► [MR-ANGIOGRAPHY](#) (.pdf)

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by [healthcare.siemens.com](#)

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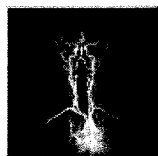
## Angiography

Angiography means the imaging of veins and arteries. Magnetic resonance angiography (MRA) has a lower invasion than conventional angiography with catheter and X-ray contrast agent. Time of flight angiography (inflow) and phase contrast angiography works without contrast agents. Only in contrast enhanced magnetic resonance angiography is the use of contrast agents necessary, but the lack of side effects is an advantage of MRI contrast agents, just as the smaller dosage as used in X-ray angiography techniques.

See also the related poll result: 'MRI will have replaced 50% of x-ray exams by'

## Images, Movies, Sliders:

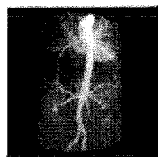
► [CE-MRA of the Carotid Arteries Colored MIP](#)



Slider



► [CE MRA of the Aorta](#)



Slider



Further Reading:

## Basics:

► [MR angiography effective for diagnosing carotid artery stenosis - Patient Oriented Evidence That Matters](#)   
September 2003 by [www.findarticles.com](#)

.. There are 15 news about 'Angiography'.

## MRI Resources

Diffusion Weighted Imaging - Portals - Implant and Prosthesis pool - Coils - Knee MRI - Spectroscopy

## Circle of Willis

A large network of interconnecting blood vessels at the base of the brain that when visualized resembles a circle, the arteries effectively act as anastomoses for each other. This means that if any one of the communicating arteries becomes blocked, blood can flow from another part of the circle to ensure that blood flow is not compromised.

The circle of Willis is formed by both the internal carotid arteries, entering the brain from each side and the basilar artery, entering posteriorly. The connection of the vertebral arteries forms the basilar artery. The basilar artery divides into the right and left posterior cerebral arteries. The internal carotid arteries trifurcate into the anterior cerebral artery, middle cerebral artery, and posterior communicating artery. The two anterior cerebral arteries are joined together anteriorly by the anterior communicating artery. The posterior communicating arteries join the posterior cerebral arteries, completing the circle of Willis.

The time of flight angiography MRI technique allows imaging of the circle of Willis without the need of a contrast medium (best results with high field MRI). A cerebrovascular contrast

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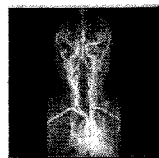
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enhanced magnetic resonance angiography (MRA) depicts the circle of Willis in addition to the vessels of the neck (carotid and vertebral arteries) with one bolus injection of a contrast agent.

For Ultrasound Imaging (USI) see Cerebrovascular Ultrasonography at [US-TIP.com](http://www.us-tip.com).

#### Images, Movies, Sliders:

► CE-MRA of the Carotid Arteries 




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Further Reading:

Basics:

► [Circle of Willis](#)   
by [science.nhmccd.edu](http://science.nhmccd.edu)

News & More:

► [Image Gallery - Division of Academic Radiology - University of Nottingham](#)   
by [www.nottingham.ac.uk](http://www.nottingham.ac.uk)

#### Contrast Enhanced Magnetic Resonance Angiography

(CE MRA) Contrast enhanced MR angiography is based on the T1 values of blood, the surrounding tissue, and paramagnetic contrast agent.

T1-shortening contrast agents reduces the T1 value of the blood (approximately to 50 msec, shorter than that of the surrounding tissues) and allow the visualization of blood vessels, as the images are no longer dependent primarily on the inflow effect of the blood. Contrast enhanced MRA is performed with a short TR to have low signal (due to the longer T1) from the stationary tissue, short scan time to facilitate breath hold imaging, short TE to minimize T2\* effects and a bolus injection of a sufficient dose of a gadolinium chelate.

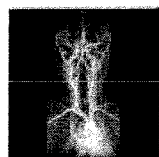
Images of the region of interest are performed with 3D spoiled gradient echo pulse sequences. The enhancement is maximized by timing the contrast agent injection such that the period of maximum arterial concentration corresponds to the k-space acquisition. Different techniques are used to ensure optimal contrast of the arteries e.g., bolus timing, automatic bolus detection, bolus tracking, care bolus. A high resolution with near isotropic voxels and minimal pulsatility and misregistration artifacts should be striven for. The postprocessing with the maximum intensity projection (MIP) enables different views of the 3D data set.

Unlike conventional MRA techniques based on velocity dependent inflow or phase shift techniques, contrast enhanced MRA exploits the gadolinium induced T1-shortening effects. CE MRA reduces or eliminates most of the artifacts of time of flight angiography or phase contrast angiography. Advantages are the possibility of inplane imaging of the blood vessels, which allows to examine large parts in a short time and high resolution scans in one breath hold. CE MRA has found a wide acceptance in the clinical routine, caused by the advantages:

- 3D MRA can be acquired in any plane, which means that greater vessel coverage can be obtained at high resolution with fewer slices (aorta, peripheral vessels);
- the possibility to perform a time resolved examination (similarly to conventional angiography);
- no use of ionizing radiation; paramagnetic agents have a beneficial safety.


#### Images, Movies, Sliders:

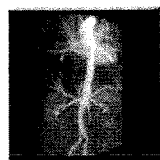
► CE-MRA of the Carotid Arteries 



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► CE MRA of the Aorta 



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► CE-MRA of the Carotid Arteries Colored MIP 







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












 Further Reading:

Basics:

- Contrast-Enhanced MR Angiography  (.pdf)   
by ric.uthscsa.edu
- CONTRAST ENHANCED MR ANGIOGRAPHY - PRINCIPLES, APPLICATIONS, TIPS AND PITFALLS  (.pdf) 

News & More:

- CONTRAST-ENHANCED MRA OF THE CAROTIDS  (.pdf) 
- PERIPHERAL VASCULAR MAGNETIC RESONANCE ANGIOGRAPHY  (.pdf) 
- CONTRAST ENHANCED MRI OF THE LIVER STATE-OF-THE-ART  (.pdf) 
- NEUROVASCULAR MAGNETIC RESONANCE ANGIOGRAPHY  (.pdf) 
- 3D MRA Visualization and Artery-Vein Separation Using Blood-Pool Contrast Agent MS-325, Academic Radiology, Vol 9, Suppl 1, 2002  (.pdf)   
2002 by www.academicradiology.com [Free, but registration is required.]
- 13C-Angiography  (.pdf)   
2002 by www.academicradiology.com [Free, but registration is required.]

•• There are 2 news about 'Contrast Enhanced Magnetic Resonance Angiography'.

● Flow



Flow phenomena are intrinsic processes in the human body. Organs like the heart, the brain or the kidneys need large amounts of blood and the blood flow varies depending on their degree of activity. Magnetic resonance imaging has a high sensitivity to flow and offers accurate, reproducible, and noninvasive methods for the quantification of flow. MRI flow measurements yield information of blood supply of various vessels and tissues as well as cerebro spinal fluid movement.

Flow can be measured and visualized with different pulse sequences (e.g. phase contrast sequence, cine sequence, **time of flight angiography**) or contrast enhanced MRI methods (e.g. perfusion imaging, arterial spin labeling).

The blood volume per time (flow) is measured in: cm<sup>3</sup>/s or ml/min. The blood flow-velocity decreases gradually dependent on the vessel diameter, from approximately 50 cm per second in arteries with a diameter of around 6 mm like the carotids, to 0.3 cm per second in the small arterioles.

Different flow types in human body:

- Behaves like stationary tissue, the signal intensity depends on T1, T2 and PD = Stagnant flow
- Flow with consistent velocities across a vessel = Laminar flow
- Laminar flow passes through a stricture or stenosis (in the center fast flow, near the walls the flow spirals) = Vortex flow
- Flow at different velocities that fluctuates = Turbulent flow

See also Flow Effects, Flow Artifact, Flow Quantification, Flow Related Enhancement, Flow Encoding, Flow Void, Cerebro Spinal Fluid Pulsation Artifact, Cardiovascular Imaging and Cardiac MRI.

Images, Movies, Sliders:

▶ MVP Parasternal 

Courtesy of Robert R. Edelman

 Further Reading:



## Basics:

▶ EVALUATION OF THE VASCULAR SYSTEM WITH MAGNETIC RESONANCE ANGIOGRAPHY: MORPHOLOGICAL ASSESSMENT AND FLOW QUANTIFICATION  (.pdf) 

•• There are 7 news about 'Flow'.

 **MRI Resources**

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